METHOD AND APPARATUS FOR SYNCHRONIZING SUBSCRIBER EQUIPMENT WITH BASE STATIONS IN A CDMA RADIO NETWORK

Method for synchronizing subscriber equipments, a base station and a subscriber equipment

BACKGROUND OF THE INVENTION

The invention relates to a method for synchronizing subscriber equipment with the transmission of a base station in a digital cellular radio network utilizing the CDMA multiple access method, and comprising in each cell at least one base station communicating with subscriber equipment within its area, and in which network the base station transmits a separate pilot channel provided with a predetermined spreading code.

Code Division Multiple Access (CDMA) is a multiple access method, which is based on the spread spectrum technique and which has been applied recently in cellular radio systems, in addition to the earlier-developed FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access) methods. CDMA has several advantages over those earlier developed methods, for example spectral efficiency, the simplicity of frequency planning, and traffic capacity.

In the CDMA method, the narrow-band data signal of the user is multiplied to a relatively wide band of a traffic channel by a spreading code having a considerably broader band than the data signal. In known cellular network test systems, bandwidths such as 1.25 MHz, 10 MHz and 25 MHz have been used. In connection with multiplying, the data signal spreads to the entire band to be used. All users transmit by using the same frequency band, i.e. traffic channel, simultaneously. A separate spreading code is used over each connection between a base station and a subscriber equipment, and the signals of the users can be distinguished from one another in the receivers on the basis of the spreading code of each connection.

Correlators provided in conventional CDMA receivers are synchronized with a desired signal, which they recognize on the basis of a spreading code in the signal. The data signal is restored in the receiver to the original band by multiplying it again by the same spreading code as at the transmission stage. Signals multiplied by some other spreading code at the transmission stage do not correlate in an ideal case with the spreading code used in the receiver and are not restored to the narrow band. They appear thus as noise with respect to the desired signal. The spreading codes of the system are preferably selected in such a way that the codes used in each system cell are mutually orthogonal, i.e. they do not correlate with each other.

In a typical mobile phone environment, the signals between a base station and a mobile station propagate along several paths between the transmitter and the receiver. This multipath propagation is mainly due to the reflections of the signal from the surrounding surfaces. Signals which have propagated along different paths arrive at the receiver at different times due to their different transmission delays. CDMA differs from the conventional FDMA and TDMA in that the multipath propagation can be exploited in the reception of the signal. The receiver generally utilized in a CDMA system is a so-called rake receiver, which consists of one or more rake branches. Each branch is an independent receiver unit, the function of which is to compose and demodulate one received signal component. Each rake branch can be caused to synchronize with a signal component which has propagated along an individual path, and, in a conventional CDMA receiver, the signals of the receiver branches are preferably combined, whereupon a signal of good quality is achieved.

The signal components received by the branches of a CDMA receiver may be transmitted from one, or several base stations. The latter case is called macro diversity, which is a form of diversity by means of which the quality of a connection between a mobile station and a base station can be improved. In CDMA cellular radio networks, the macro diversity, which is also called "soft handover", is used to ensure the efficiency of power control near the borders of base stations, and to enable smooth handover. In macro diversity, a mobile station thus communicates simultaneously with two or more base stations. The same information is transmitted over each connection.

In a CDMA cellular radio system, it is possible to use a so-called pilot channel in the transmission direction of base to subscriber equipment, i.e. in the downlink direction. A pilot channel is a signal which is transmitted with a specific spreading code and utilizing the same frequency band on which the actual traffic channels are situated, the pilot signal being distinguishable from them only on the basis of the spreading code. The pilot signal is a channel known and listened to by all subscriber equipments within the cell area, and it is used for example in power measurements and in the generation of a coherent phase reference. Each base station of the system transmits its own pilot signal on the basis of which the subscriber equipment can distinguish the transmissions of different base stations from each other. In CDMA, all base stations may transmit using the same frequency band.

U.S. Pat. No. 5,109,390 and EIA/TIA Interim Standard: Mobile Station—Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum-Cellular System, TIA/EIA/IS-95, July 1993, which are referred to here, disclose a prior art CDMA cellular radio system employing a separate pilot channel which is transmitted by utilizing a predetermined spreading code. The signal of the pilot channel is data-unmodulated, i.e. it contains no data information.

FIG. **1** shows a prior art arrangement for generating a pilot signal in a base station, where a signal **10** comprising only zero symbols (000 . . .) is multiplied in a multiplier **12** with the spreading code **11** of the pilot signal. The obtained signal is multiplied with a carrier frequency OSC1 in a multiplier **13**, filtered with a transmission filter **14**, and transmitted by means of an antenna **15**. The pilot signal thereby contains no data information, but only the spreading code.

As described above, a subscriber equipment must synchronize itself with a signal it has received from a base station. There are two kinds of situations where synchronization is needed: during call set-up and during handover. In CDMA, it is also possible to distinguish synchronization of two different levels: code and frame synchronization. In the prior art arrangements, the signal of the pilot channel is used to achieve code synchronization, whereas frame synchronization is provided by means of separate control channels. Known arrangements have required the use of two separate control channels for this purpose.

When soft handover is to be made between two base stations, i.e. when a connection is to be maintained simultaneously with more than one base station, the terminal equipment should be synchronized with both base stations. If the system is synchronous, i.e. the base stations have a common clock signal, e.g. a GPS signal, the synchronization